

May 18, 1965

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3,183,996

ACOUSTICAL STRUCTURAL PANEL

Filed Sept. 4, 1959

2 Sheets-Sheet 1

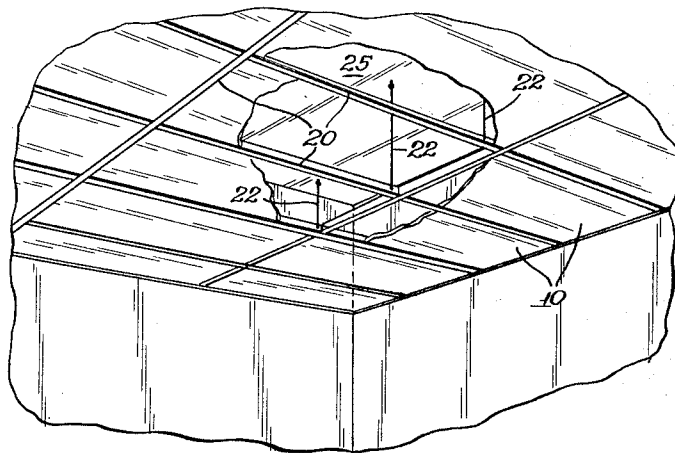


Fig. 1.

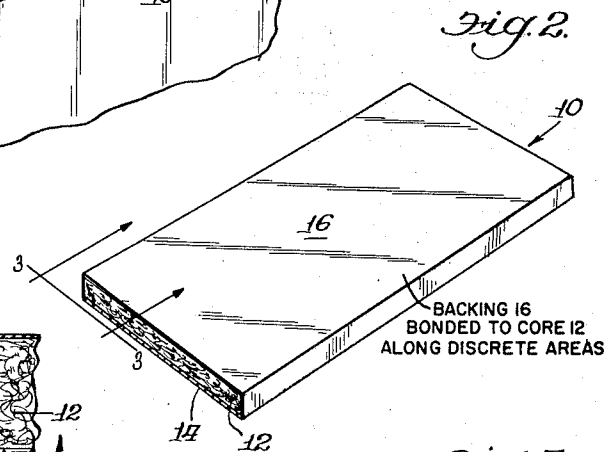


Fig. 2.

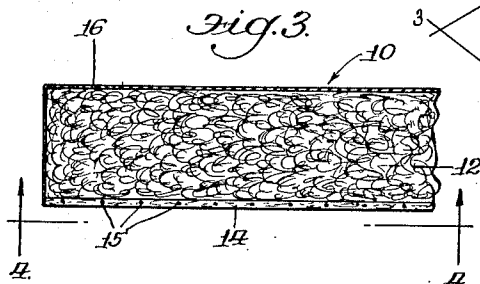


Fig. 3.

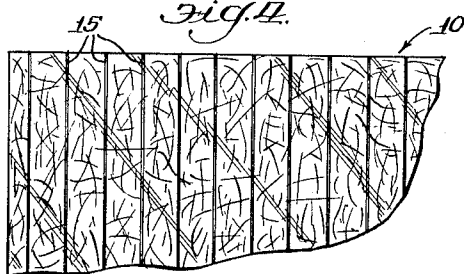


Fig. 4.

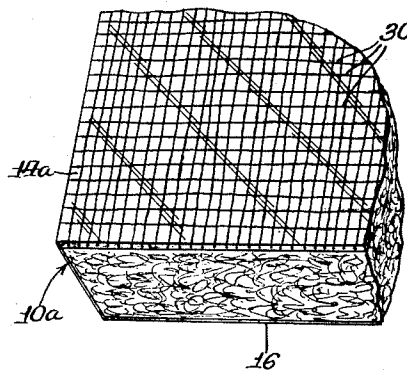


Fig. 5.

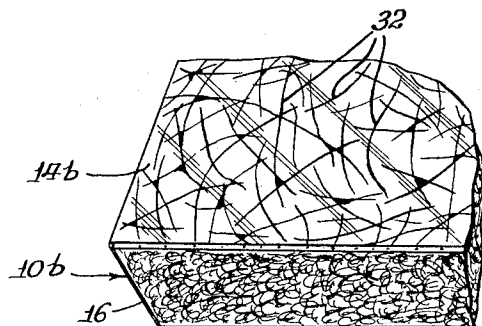


Fig. 6.

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Fig. 8.

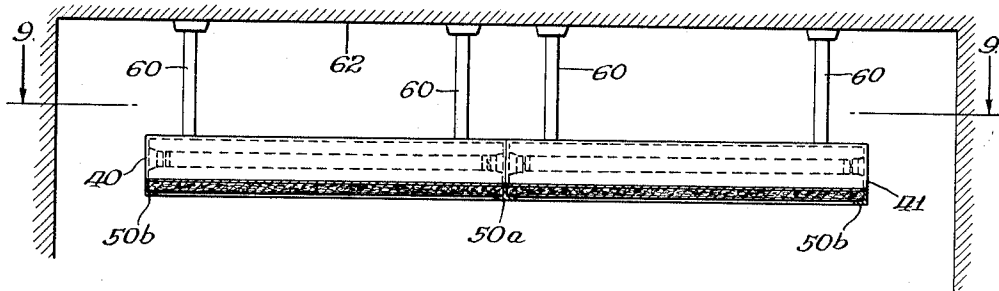


Fig. 9.

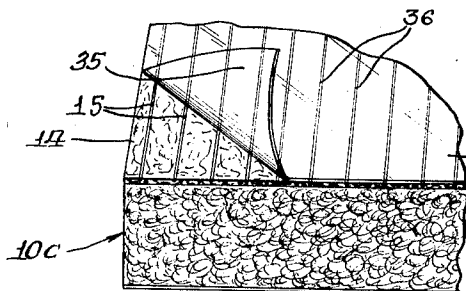
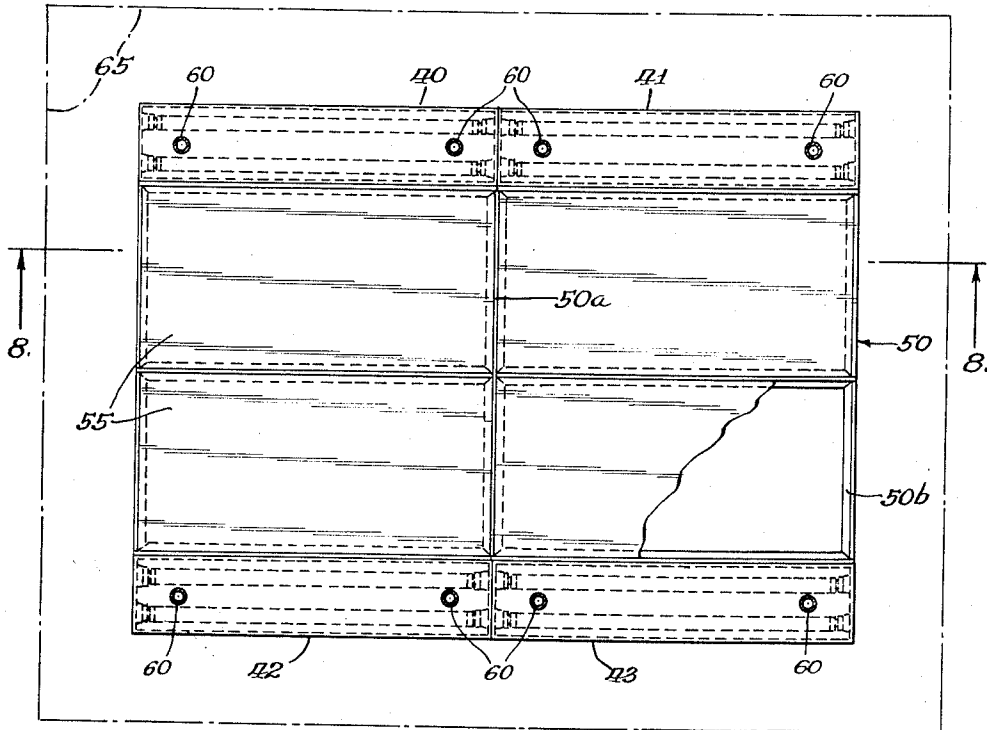


Fig. 7.

FILM 35 AND
MAT 14 ADHERED
BY ADHESIVE

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3,183,996

ACOUSTICAL STRUCTURAL PANEL

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12 Claims. (Cl. 181—33)

This invention relates to structural panels and more particularly to panels of a sandwich type construction useful as ceiling board to provide desirable acoustical and thermal insulating properties.

Present day interior construction frequently requires the use of material having high sound absorption properties as well as resistance to fire. For example, the ceiling of offices, industrial workrooms, or commercial buildings are often covered with mineral type panels or boards for these reasons. Obviously, such boards also play an important role in the decoration of an area in which they are used and it is desirable that they be producible in various patterns, textures and colors in order to find wide acceptance.

There are further considerations in the design and manufacture of panels for ceilings and the like, such as the ability to provide thermal insulation, that is, to prevent heat transfer through the panels so as to improve summer cooling and winter heating of the enclosed areas. Furthermore, it is an advantage for such panels to limit "breathing" or air flow therethrough and to be constructed in a way promoting simple and inexpensive installation.

In prior known structural panels constructed of mineral wool (composed of rock, slag or glass fibers) difficulty has been experienced in economically constructing the panels with the necessary structural rigidity for satisfactory service and simplified installation, while at the same time retaining all of the above described desirable properties in the panel structure.

For example, it has been necessary to use material of relatively high density (e.g. 20 lbs. per cubic foot) in order to obtain proper rigidity of the panels for self-support and to reduce the breathing or air flow through the panels. This increases the cost and weight to an undesirable extent. Some prior art panels have been constructed with relatively great thickness, that is, of the order of one and one-half to two inches or more in order to increase the absorption of acoustical energy but this aggravates the disadvantage of increasing density to reduce breathing. Glass fiber (having a molal acid to base ratio of well over 1.0) panels have been made in this form, but relatively great thickness or density and large amounts of binder have been necessary, resulting in panels that do not fully solve the sound absorption and breathing problems in a light weight economical product.

Furthermore, to successfully provide low sound transmission through such panels, it has not been uncommon to include an additional non-porous board or enclosure member behind the main acoustical panel and this practice also increases the installation time and the cost of the installation.

Accordingly, it is an object of this invention to provide an improved mineral wool structural panel which may be economically constructed and is light in weight, even when formed in relatively large sizes, and which possesses structural rigidity so as to simplify the supporting means for the panel.

Another object is to provide increased absorption of acoustic energy in mineral wool type ceiling board so that it is highly effective in deadening sound in an area by absorbing, and not reflecting, sound impinging on the face surface and by greatly retarding sound transmission through the board.

A further object is to provide an acoustical absorption rock or slag wool panel having a desirably decorative face surfacing and an improved construction which inhibits heat transfer therethrough or air passage there-

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through. (Rock or slag wool herein is intended to mean mineral wool with a molal acid to base ratio on the order of 1.0 or less.)

A feature of the invention is the provision of an improved sandwich type structural panel having a low density slag wool core, a reinforced facing comprising a fiber glass mat, and a reflective, flexible backing sheet.

Another feature is the provision of a ceiling panel having a reinforced facing of glass fiber with parallel strands of fiber glass yarn extending longitudinally of the panel and a flexible backing sheet secured along sections of the panel back to form a rigid panel for use in relatively large sizes.

A further feature is the provision of a panel having a mineral wool core, a membrane facing for strength and decorative purposes and a flexible backing, such as aluminum coated paper, which is secured only along discrete sections of the panel back in order to block air and heat transfer through the panel and to form a sound energy reflector flexible with respect to the panel.

In the drawings:

FIG. 1 is a perspective fragmentary view showing the structural panels as they may be used in forming a room ceiling;

FIG. 2 is a perspective view, on an enlarged scale with respect to the showing of FIG. 1, of the back of a structural panel as used in the ceiling of FIG. 1;

FIG. 3 represents a view, on an enlarged scale with respect to the showing of FIG. 1, along the line 3—3 of FIG. 2;

FIG. 4 is a face view of the panel along the line 4—4 of FIG. 3;

FIG. 5 is a fragmentary perspective view of a panel having a modified face construction;

FIG. 6 is a fragmentary perspective view of a panel having another modified face construction;

FIG. 7 is a fragmentary perspective view of a panel with a still further modified facing construction;

FIG. 8 is a sectional view of a ceiling panel and lighting structure along line 8—8 of FIG. 9; and

FIG. 9 is a plan view of the structure of FIG. 8 along the line 9—9; however the tile on the lower right is shown partially broken away to expose details of the framework members.

Briefly, in a particular form, the structural panel comprises a slag wool slab approximately 1 inch in thickness with fine random fibers and having a low density (of the order of seven (or less) pounds per cubic foot). A laminated face of the panel comprises a glass fiber mat having random fibers to give strength to the panel and to form a surface for decorative finishing, such as painting or the like. Preferably the glass fiber mat includes parallel strands of glass yarn to give increased rigidity to the slab. The back surface of the panel is covered by a flexible membrane, such as a paper backing, which is cemented to the panel only along limited areas and this further improves the rigidity of the panel. Due to the manner of securing the backing to the panel this backing can flex away from the panel back as sound energy tends to pass through the panel thereby reflecting this energy back into the panel core for further absorption. The flexible backing may also be aluminum coated for thermal reflectivity to enhance the insulating properties of the panel. Panels formed in this sandwich form have sufficient rigidity to be constructed in relatively large size for example, four feet by four feet, and to be retained only along the edges thereof in a ceiling suspended grid system. Various supporting methods may be used or the panels may be retained by means of supporting members affixed to ceiling light fixtures and carried by the lighting support means in an improved suspending structure which is feasible due to the light-weight, rigid construction of the panels.

The board or panel 10 shown in FIGS. 2-4 includes a core 12 composed of slag wool and is specifically comprised of various silicates in fibrous form having fiber diameters of the order of .0005" or less and all bonded together by a suitable binder such as phenolic resin. The glass fiber mat 14 is bonded to the surface of the semi-rigid core 12 by a suitable means such as phenolic resin. This mat may have a thickness of the order of 20 mils and is composed of random glass fibers having diameters of the order of the fiber diameter in the core 12. Mat 14 further includes parallel extending strands 15 of glass yarn which extend longitudinally of the panel 10 and these may be spaced approximately 1/4 inch to 3/8 inch apart.

The panel 10 is covered on its back surface by a flexible backing 16 which is bonded to the core 12 only along discrete areas or strips and the outer peripheral edge of the back of the panel. The backing 16 may be secured to the core 12 by sodium silicate or some other suitable bonding material. Backing 16 may be composed of forty pound flame proof kraft paper coated with aluminum flakes, or aluminum foil. The backing 16 may further extend over the longitudinal edges of the panel and be bonded thereto as shown in FIGS. 2 and 3.

The mat 14 and the backing 16 both provide structural rigidity to the entire panel. Because of this construction it is possible to form the core 12 of relatively low density slag wool, e.g. of the order of six pounds per cubic foot. As shown in FIG. 2, the panel is a ceiling board having a thickness of approximately one inch and a width of two feet and a length of four feet. The described board construction is particularly adapted for use in panels of this size which may be suspended in spaced relation from a ceiling as shown in FIG. 1.

In an installation as illustrated in FIG. 1, a grid work of supporting members 20 is suspended by means of wires 22 or other suitable means from an upper closure 25. The members 20 have cross-sections which are in the form of an inverted T and these members may be formed with precise dimensions so as to lock together in interconnected form to define rectangular spaces into which the tile 10 may be dropped. Thus, after a grid frame has been installed and suspended as illustrated, the individual boards are turned and passed through a grid rectangle from underneath and then to the space between the grid work and the upper enclosure 25 and then turned to be aligned with the members 20 and dropped into place to be supported by the member 20 along the periphery of the face of the board. Since the boards may be constructed in a large size, large areas can be rapidly and effectively enclosed. Furthermore, the boards are removable for access to the space above them should this be necessary.

In installations of the type shown, it is necessary that each panel have sufficient rigidity to remain in place without sagging and that the panel withstand handling during the installation operation. With the particular construction as described, it is possible to use an economical, low density, slag wool core while still retaining these necessary and desirable structural properties, as well as extremely favorable acoustical and thermal properties.

The panel strength is provided in large measure by the sandwich construction and particularly by the glass fiber mat 14 with its parallel strands 15 of glass fiber yarn extending across the panel facing. The mat 14 further provides a surface which may be painted for decoration and light reflecting purposes, and this mat forms a surfacing on the semi-rigid core 12 which improves the handling capabilities of the panel and its slag wood core.

The backing 16 is also desirable from the standpoint of workmen handling the panel without damage or discomfort in coming in contact with the core 12. It should further be clear that bonding the paper backing 16 to the core 12 along the discrete strips of the back of the core, will further improve the strength of the entire panel. In addition, however, the backing 16 provides other very desirable properties to the panel.

Since the paper backing 16 is not bonded to the entire

surface of the back of the panel it has been found that the backing 16 may actually flex or billow outwardly when any unabsorbed sound energy is transferred through the panel and thus the backing tends to absorb energy from the sound. Furthermore, the backing 16 reflects such largely dissipated sound energy back into the panel where it can be absorbed in the core 12 rather than permitting it to radiate into the space between the installed panel and the enclosure 25 where it could be translated to other areas. Thus, while the core 12 has substantial sound absorbing properties due to its thickness and physical composition, the acoustical properties of the overall panel 10 are greatly promoted by action of the backing 16. It may also be noted that if sound energy does enter the spacing above an installed set of panels, for example from another room or enclosed area, most of this energy will be directly reflected upwardly from the backing 16 and any small remainder of this energy will pass into core 12 to be absorbed. Thus, sound above the panels tends not to enter the area below, and the area below is insulated from such extraneous sounds. Furthermore, since the panels may be formed to provide a snug fit in the grid work, there will be no leakage or passage of sound around a complete acoustical panel sandwich as is the case with a heavy density loose fitting board, which may even have a non-porous panel installed in back of it.

In actual tests of the acoustical properties of a tile constructed in accordance with the present description, an overall noise reduction coefficient of .90 has been obtained. The particular coefficients at different sound frequencies resulting in this overall noise reduction coefficient are as follows:

Frequency -----	125	250	500	1000	2000	4000
Coefficient -----	.73	.89	.89	.92	.91	.90

Such tests were based on conditions set forth as mounting No. 7 (9 3/4" air space) by the American Society for Testing Materials for Sound Absorption of Acoustical Materials in Reverberation Rooms and is under designation C423-58T. It should be noted that the sound reduction is relatively uniform throughout the range and relatively high in the low frequency region. In contrast, other present day panels of comparable type may weigh much more and cost more and have coefficients significantly less. Accordingly, the panels of this invention has rating specifications which exceed those of other types of acoustical insulating materials while still maintaining advantages not found in prior art constructions.

The backing 16 also provides desirable thermal insulating properties for the panel 10 and this is promoted by coating the paper backing with aluminum flake so that it will reflect heat. Thus, if a ceiling of the panels is installed immediately under a roofing area, the heat of the roof will be largely retained above the ceiling due to the heat reflecting properties of the aluminum coated paper backing 16. Furthermore, under low temperature conditions backing 16 will tend to maintain heat within the area beneath the panel and to insulate that area from cold air above the panels. The actual U factors (relative thermal transfer of panels with multi-layer cross section) realized for summer are less than .15 and less than .20 for winter.

Backing 16 additionally reduces "breathing" through the panel 10. This action tends to occur when the area above the installed panel is cooler than the area below the panels in which case the tendency is for air passage across the panel from the facing toward the backing. In addition to heat loss this would further tend to carry dirt to the surface of the panel or mat 14. However, the backing 16 prevents such air passage across the panel and thus breathing therethrough is effectively eliminated. From the overall acoustic, thermal, and non-breathing properties of the panel it is therefore possible to position the panels immediately below (approximately one foot) an upper enclosure, such as closure 25, without the use of an intervening panel or an intermediate ceiling structure.

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In further considering the desirable properties of the overall panel construction it may be noted that the panels will exhibit a high degree of flame resistance. A panel constructed as described is rated as Class A (incombustible) under the standards of the Acoustical Society of America, using methods set forth in Fed Spec. SSa-118b. This is due, of course, to the use of mineral fibers and flame proof material in a manner to greatly retard any tendency for supporting combustion.

As shown in FIG. 5 the panel 10a has a mat 14a modified so as to comprise interwoven strands 30 of glass yarn to form a facing providing structural rigidity to the panel. The warp and woof may be formed of different size yarns (not shown).

FIG 6 illustrates a further modification in the form of a panel 10b having a mat 14b on the face surface thereof. Mat 14b is composed of random filaments 32 of glass yarn (e.g. 1 to 1½" long) which are bonded together to provide a mat having considerable texture to its surface. It is then possible to create various decorative effects in using a mat of this type since it can be painted or otherwise colored in various ways, for example, by painting only the outward relief portions of the mat.

FIG. 7 illustrates a still further modification of a panel in the form of a panel 10c having a glass fiber facing mat 14 which corresponds to the mat 14 of the panel of FIGS. 2-4. However, covering the face surface of the mat 14 there is a thin plastic film 35 which covers the entire surface of the panel and is partially adhered in a discrete manner. The film 35 may be, for example, composed of Mylar (.0005 inch thick) and this gives a further seal for air passage through the panel in addition to providing a surface which may be printed, painted or otherwise decorated with various patterns to enhance the esthetic appearance of the panel when installed. The film 35 is preferably adhered to about 50 percent by coating mat 14 with flexible adhesive, and applying a Mylar film at 150° C. which shrinks it slightly so that it is adhered only along slight ridges 36 formed by the yarn strands 15 in mat 14. Other film material may also be adhered or even sprayed on the panel face. In fact, a film or membrane of proper strength can replace the face mat and become the sole facing in low density panels of the invention.

As shown in FIGS. 8 and 9, it is also contemplated that the panels of the invention may be utilized in conjunction with suspending framework which is carried by lighting fixtures to form a highly effective unit to illuminate a room, decorate the ceiling area thereof, and provide substantial sound absorption in the area. As shown, the fluorescent lighting fixtures 40 and 41 are elongated units which are mounted end to end. Corresponding similar lighting fixtures 42 and 43 are also mounted end to end and between these two fixtures, supported thereby and integral therewith, is a frame work 50 composed of members 50a in the shape of an inverted T and members 50b in the shape of an L. The members of the frame 50 define rectangular spaces into which the tiles 55 may be inserted from above the entire unit so that the boards are carried by the members 50a and 50b.

Since the panels of the invention are of lightweight construction and require but an extremely simple operation for installation, it is possible to install the lighting fixtures 40-43 by means of the usual supporting posts 60 which are affixed to the ceiling or upper enclosure 62 and which may also carry the usual wiring (not shown) for the fixtures. Since the panels are of such light weight, further supports are not needed. The panels 55 are simply inserted so that the installation for the entire unit involves little more than the usual installation of lighting fixtures.

In practical use various numbers of lighting fixtures such as fixture 40 and various lengths of framing members such as members 50a and 50b can be utilized to provide complete lighting and acoustic units of different sizes containing different numbers of lighting fixtures and dif-

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ferent numbers of panels. Thus, in any given area or room such as defined by lines 65 it would be possible to install a lighting and an acoustical ceiling unit which would extend substantially over the entire room area.

This is also a convenient way to lower a ceiling height if desired. Acoustical panels of the present invention provide sufficient sound absorption that very effective sound deadening can still be accomplished even though the entire room ceiling is not covered by the panel. For example, covering two thirds or more of the area can be very effective. This sound absorption effectiveness is due to the sandwich construction of the entire panel as previously discussed.

As should be apparent from the foregoing description, the structural panels of the present invention possess very great sound absorption properties and provides reduction of sound transmission through the panel as well as reduction of sound reflection for energy impinging upon one side of the panel. The improved results obtained with the described laminar or sandwich type construction are believed to be due to the favorable relation of weight to flexibility, that is the overall bulk and weight of the panel and the nature of the core material which is somewhat soft and spongy and has an "elemental flexibility" for absorption at sound energy frequencies. The laminated face surface and the flexible backing sheet also assist in sound deadening as previously described and, of course, the facing mat permits the passage of sound energy to be absorbed in the core while the backing sheet reflects sound energy to prevent its transfer across the panels. However, an equally important function of the panel facing and backing sheets is to provide overall structural rigidity to the panel so that they can be self-supporting in a simplified peripheral support system. It should also be pointed out that the facing layer is sound absorptive and not sound reflective while the backing sheet is sound reflective and not sound absorptive so that there will be no sound reflection problems within the panel itself.

This invention provides, therefore, an improved structural panel which is of economic construction and extremely effective in controlling sound energy. Furthermore, the panel has highly desirable thermal insulating properties and it may be constructed with various surface textures or coloring so as to meet various requirements of interior decoration.

I claim:

1. A unitary structural panel having rigidity to be edge supported, said panel comprising a relatively thick core of mineral wool and binder means therefor forming a flat semirigid panel having front and back surfaces, a relatively thin glass fiber mat bonded to the entire front surface of said panel and including bonded, interlocked strands of glass fibers for imparting structural rigidity to said semirigid panel, and a flexible backing sheet bonded only along discrete areas to the back surface of said panel to inhibit air passage and thermal transfer through said panel and to absorb and reflect sound energy traversing through said panel.

2. A unitary structural panel having a rigidity to be edge supported, said panel comprising a relatively thick core of slag wool and binder means therefor forming a flat semirigid panel having opposite faces, a relatively thin glass fiber mat bonded to one face of said panel and including random strands of glass fibers and spaced parallel strands of glass fiber yarn for imparting structural rigidity to said semirigid panel, and a flexible paper backing sheet bonded to the other face of said panel to inhibit air passage and thermal transfer through said panel.

3. A unitary structural panel having rigidity to be edge supported, said panel comprising a relatively thick core of mineral wool and binder means therefor forming a flat semirigid panel having front and back faces, a relatively thin glass fiber mat bonded to the entire front face

of said panel and including strands of glass fiber yarn for imparting structural rigidity to said semirigid panel, a thin film affixed to the outer face of said mat to form a decorative facing film for said panel, and a backing sheet bonded to the back face of said panel to inhibit air passage and thermal transfer through said panel.

4. A unitary structural panel of sandwich construction having rigidity to be edge supported, said panel comprising a core of slag wool and binder means therefor forming a semirigid panel having outwardly facing surfaces and a density of the order of 6 pounds per cubic foot and a thickness of the order of one inch, a sound transmitting facing layer bonded to one surface of said panel for imparting structural rigidity to said panel, and a sound reflective, flexible backing sheet bonded to said panel along limited discrete areas of the other surface of said panel to inhibit air and thermal passage through said panel but to allow flexing of said backing sheet by sound energy impinging transversely of said panel.

5. A rigid structural panel to be supported in an open grid frame comprising a core of mineral wool and binder means therefor forming a flat semirigid panel having opposite faces, a facing layer bonded to an outward face of said panel and including an outwardly facing decorative membrane adhered to said facing layer for imparting structural rigidity to said semirigid panel, and a sound reflecting, flexible backing sheet bonded to the back face of said panel along discrete strips to inhibit air passage and thermal transfer through said panel, and to absorb sound energy traversing through said panel.

6. A unitary structural panel having a rigidity to be edge supported, said panel having layers to form a laminar construction, one of said layers comprising a relatively thick core of slag wool and binder means therefor forming a semi-rigid panel and having opposite faces with a uniform density of slag wool across the thickness of said panel, a relatively thin glass fiber mat bonded to the face of said panel and including random strands of glass fibers and strands of glass fiber yarn for imparting structural rigidity to the semi-rigid panel, and a membrane partially adhered to the face of said glass fiber mat to form a seal upon the surface of said panel, whereby said laminar construction provides structural rigidity for edge support of said unitary panel.

7. A unitary structural panel having rigidity to be edge supported, said panel having layers to form a laminar construction, one of said layers comprising a relatively thick core of mineral wool and binder means therefor forming a semirigid panel and having opposing surfaces with a uniform density across the thickness therebetween, a fiber glass mat layer including strands of glass fiber yarn and of lesser thickness than that of said semirigid panel adhered to one surface thereof, and a further layer adhered to the other surface of said semirigid panel to form a rigid unitary structural panel providing acoustical and thermal insulating properties.

8. The structural panel of claim 7 in which one of said layers adhered to said semirigid panel carries a decorative coating.

9. A unitary acoustical structural panel having a rigidity to be edge supported as a unit, said unitary acoustical structural panel including a plurality of layers to form a laminar construction unit, one of said layers comprising a relatively thick slab of mineral wool and binder means therefor forming a semirigid panel which is heat insulating and sound absorbing, another of said layers comprising a relatively thin and pervious glass fiber membrane including strands of glass fiber yarn and which is more flexible than the semirigid panel and which is sound transmitting, another of said layers comprising a relatively thin and substantially impervious membrane which is a barrier to air

flow and which is more flexible than the semirigid panel and which may be flexed by sound energy, said layers being bonded together with said relatively thin and substantially impervious membrane forming a face of the unitary acoustical structural panel, said bonded layers of the laminar construction providing a substantially rigid unitary acoustical structural panel to be edge supported and having acoustical and thermal insulating properties.

10. A unitary acoustical structural panel as defined in claim 9 wherein said relatively thin and substantially impervious membrane is bonded to said relatively thin and pervious glass fiber membrane.

11. A unitary acoustical structural panel having a rigidity to be edge supported as a unit, said unitary acoustical structural panel including a plurality of layers to form a laminar construction unit, one of said layers comprising a relatively thick slab of mineral wool and binder means therefor forming a semirigid panel which is heat insulating and sound absorbing, another of said layers comprising a relatively thin and pervious membrane which is more flexible than the semirigid panel and which is sound transmitting, another of said layers comprising a relatively thin and substantially impervious membrane which is a barrier to air flow and which is more flexible than the semirigid panel and which may be flexed by sound energy, said layers being bonded together with said relatively thin and substantially impervious membrane forming a face of the unitary acoustical structural panel, said relatively thin and substantially impervious membrane being bonded along only discrete areas, said bonded layers of the laminar construction providing a substantially rigid unitary acoustical structural panel to be edge supported and having acoustical and thermal insulating properties.

12. A unitary acoustical structural panel as defined in claim 11 wherein said relatively thin and substantially impervious membrane is bonded along said only discrete areas to said relatively thin and pervious membrane.

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